P. High-Density Infrared Surface Treatment of Materials for Heavy-Duty Vehicles

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Objectives

- Use high-density infrared (HDI) technology to produce corrosion-resistant and/or wear-resistant coatings on metal substrates.
- Use lighter or more cost-effective bulk materials with coatings applied to surfaces where improved properties are required.

Approach

- Examine approaches to surface modification that would be of interest for materials for heavy-duty vehicles.
- First, examine the application and formation of adherent, wear-/corrosion-resistant coatings.
- Base the initial tests on hardmetal compositions applied onto iron-based parts that are currently used in diesel engines.
- Based on these exploratory studies, ascertain further research on the use of HDI technology.

Accomplishments

- Demonstrated the ability to produce adherent hardmetal-based coatings on three different metal substrates.
- Showed improved surface hardness for HDI-produced coatings.

Future Direction

- Optimize the HDI processing parameters for coating adherence, dimensional control, and desired microstructure/phase development. Parameters to be examined include power level, scan speed, preheating effects, pulsed power effects (as compared with scanning at constant power), blanket atmosphere type, and multiple scan effects (as compared with a single scan at high power).
- Determine the effects of the different processing parameters on the coatings, as well as the substrate properties.

Introduction

HDI technology is relatively new to the materials processing area and is gradually being exploited in materials processing. The HDI processing facility at Oak Ridge National Laboratory uses a unique technology to produce extremely high power densities of 3.5 kW/cm^2 with a single lamp, which is currently the most powerful one in the world. Instead of using an electrically heated resistive element to produce radiant energy, a controlled and contained plasma is used. The advantages of the technology include these:

1. Compared with laser technology, it can cover large areas.
2. It consists of short-wavelength radiation (0.2–1.2 μm).
3. Heating and cooling is rapid.
4. It is capable of attaining very high temperatures.
5. It offers the potential for continuous processing.

Because the technology is relatively new, its utility to the surface treatment of materials for applications in heavy-duty vehicles will be explored. In most cases, the need for wear resistance, corrosion resistance, or high strength is necessary only in selected areas of the part that are exposed to the working environment or under high stress. Therefore, it would be desirable to use materials that are lighter or less expensive for the bulk of the part, and provide the appropriate surface properties only where required. In addition, the HDI approach would be more cost-effective than other competitive processes such as physical vapor deposition.

Results

The project was initiated, and three different iron-based alloys were chosen (gray cast iron, 4140 alloy steel, and D2 tool steel). Slurry coatings of WC-Ni, WC-Co, WC-Ni_3Al, and TiC-Ni_3Al were fabricated and applied by a simple cost-effective spraying technique to the surfaces of the different metals. The surfaces were then exposed to the infrared lamp under an argon cover gas. The appearance of a typical coated metal before and after HDI exposure is shown in Figures 1 and 2, respectively.

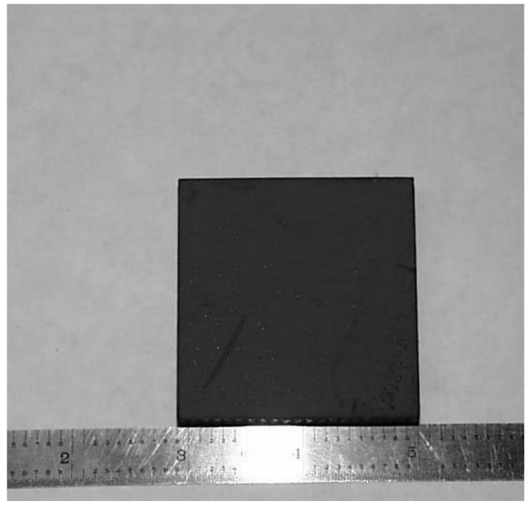

Figure 1. Visual appearance of a cast iron sample with an unprocessed WC-Ni coating on the surface.

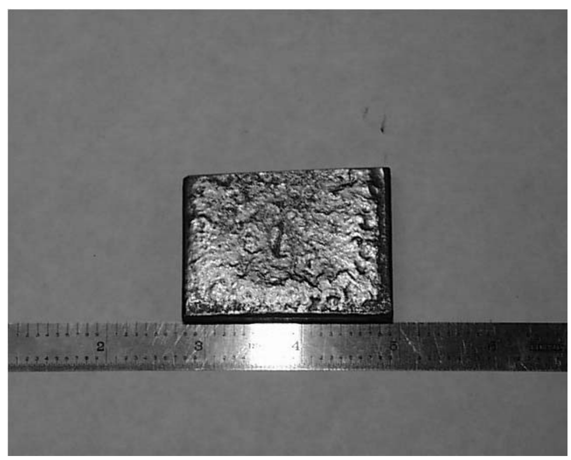

Figure 2. Visual appearance of a D2 tool steel sample with an HDI-processed WC-Ni coating on the surface.

Cross-sections of the coatings and base alloys revealed that the coatings are well bonded to the substrates, and some chemical interaction is evident (Figures 3 and 4). Some

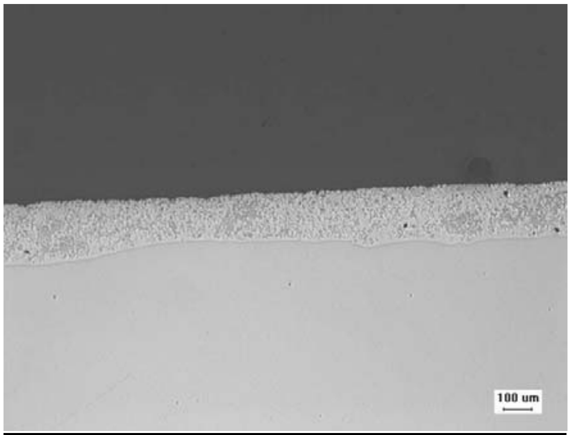

Figure 3. Cross-section of a WC-Ni coating on 4140 alloy steel after HDI processing.

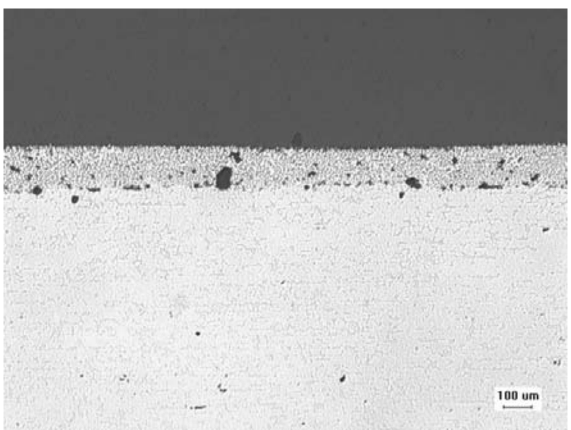

Figure 4. Cross-section of a WC-Ni_3Al coating on D2 tool steel after HDI processing.

large porosity within the coatings and at the interfaces with the underlying alloys is also observed. The coatings appear to be highly dense, although no quantitative determinations have been made to date. Initial testing showed a significant improvement of the hardness in the as-fabricated coatings (Figure 5). Interestingly, for the same coating composition, differences in hardness were observed for the three different metal substrates. Evidently, there are some mixing effects between the substrate and the coating during the high-temperature HDI exposure.

Conclusions

It was determined that adherent hardmetal-based coatings could be produced using cost-effective slurry deposition followed by bonding with the HDI lamp. Coatings were fabricated on three different metal substrates. Improved surface hardness for HDI-produced coatings was observed. It was found that the coating hardness is also a function of the substrate composition.

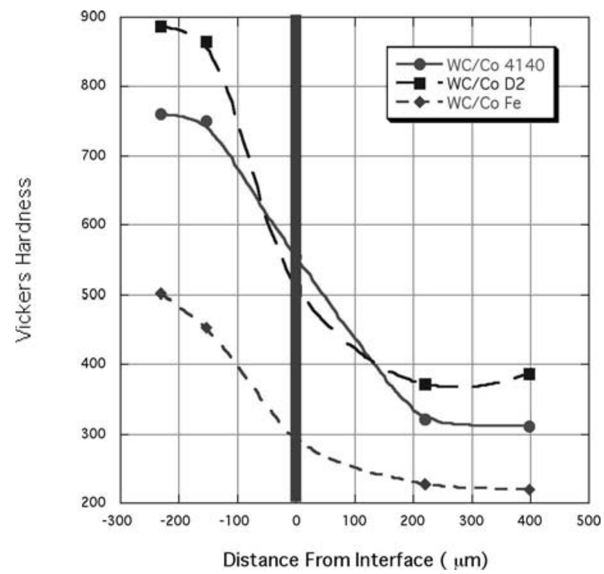

Figure 5. Hardness improvements with HDI-treated WC-Co surface coatings on 4140 alloy steel, D2 tool steel, and cast iron.